

FEDERAL AVIATION AGENCY

Washington 25, D. C.

TECHNICAL STANDARD ORDER

Regulations of the Administrator

Part 511

SUBJECT: RATE OF CLIMB INDICATOR

TSO-C86

Technical Standard Orders for Aircraft Materials,
Parts, Processes, and Appliances

Part 511 contains minimum performance standards and specifications of materials, parts, processes, and appliances used in aircraft and implements the provisions of sections 3.18, 4a.31, 4b.18, 6.18 and 7.18 of the Civil Air Regulations. The regulation uses the Technical Standard Order system which, in brief, provides for FAA-industry cooperation in the development of performance standards and specifications which are adopted by the Administrator as Technical Standard Orders, and a form of self-regulation by industry in demonstrating compliance with these orders.

Part 511 consists of two subparts. Subpart A contains the general requirements applicable to all Technical Standard Orders. These provisions are summarized below for the convenient reference of the public. Subpart B contains the technical standards and specifications to which a particular product must conform, and each Technical Standard Order is set forth in the appropriate section of Subpart B. The subject Technical Standard Order is printed below. ANY TECHNICAL STANDARD ORDER MAY BE OBTAINED BY SENDING A REQUEST TO FAA, WASHINGTON 25, D. C.

SUBPART A--GENERAL

This subpart provides, in part, that a manufacturer of an aircraft material, part, process, or appliance for which standards are established in Subpart B, prior to its distribution for use on a civil aircraft of the United States, shall furnish a written statement of conformance certifying that the material, part, process, or appliance meets the applicable performance standards established in this part. The statement of conformance must be signed by a person duly authorized by the manufacturer, and furnished to the Chief, Engineering and Manufacturing Division, Bureau of Flight Standards, Federal Aviation Agency, Washington 25, D. C.

Subpart A also requires appropriate marking of materials, parts, processes, and appliances as follows:

- (a) Name and address of the manufacturer responsible for compliance,
- (b) Equipment name, or type or model designation,
- (c) Weight to the nearest pound and fraction thereof,
- (d) Serial number and/or date of manufacture, and
- (e) Applicable Technical Standard Order (TSO) number.

In addition, Subpart A provides that no deviation will be granted from the performance standards established in Subpart B, and that the Administrator may take appropriate action in the event of noncompliance with Part 511.

SUBPART B

§514.18 Rate of climb indicator, pressure actuated (vertical speed indicator) - TSO-C8b--(a) Applicability--(1) Minimum performance standards. Minimum performance standards are hereby established for rate of climb indicators, pressure actuated (vertical speed indicator) which specifically are required to be approved for use on civil aircraft of the United States. New models of rate of climb indicators, pressure actuated (vertical speed indicator) manufactured for installation on civil aircraft on or after April 1, 1959, shall meet the standards set forth in SAE Aeronautical Standard AS-394A, "Rate of Climb Indicator, Pressure Actuated (Vertical Speed Indicator)," dated July 15, 1958,¹ with the exceptions listed in subparagraph (2) of this paragraph. Rate of climb indicators, pressure actuated (vertical speed indicator) approved by the Administrator prior to April 1, 1959, may continue to be manufactured under the provisions of their original approval.

(2) Exceptions. (i) Conformance with the following sections is not required: 3.1; 3.1.1; 3.1.2; 3.2; 4.2.1.

(ii) Substitute the following for section 7.: "Performance tests: The following tests in addition to any others deemed necessary by the manufacturer, shall be the basis for determining compliance with the performance requirements of this standard."

(b) Marking. In lieu of the weight specified in paragraph (c) of §514.3, the following shall be shown:

(1) Instrument type (I, II, III or IV)

(2) Range (feet per minute climb and descent).

(c) Data requirements. One copy each of the manufacturer's operating instructions, schematic diagrams, and installation procedures shall be furnished the Chief, Engineering and Manufacturing Division, Federal Aviation Agency, Washington 25, D. C., with the statement of conformance.

(d) Effective date. April 1, 1959.

¹/Copies may be obtained from the Society of Automotive Engineers, Inc., 485 Lexington Ave., New York 17, New York.

RATE OF CLIMB INDICATOR, PRESSURE ACTUATED (VERTICAL SPEED INDICATOR)

Issued 8/1/47
Revised 7/15/58

1. PURPOSE: To specify minimum requirements for pressure, actuated Climb Indicators for use in aircraft, the operation of which may subject the instruments to the environmental conditions specified in paragraph 3.3.
2. SCOPE: This Aeronautical Standard covers four (4) basic types of direct indicating instruments as follows:

TYPE I - Range 0-2000 feet per minute climb and descent
TYPE II - Range 0-3000 feet per minute climb and descent
TYPE III - Range 0-4000 feet per minute climb and descent
TYPE IV - Range 0-6000 feet per minute climb and descent
3. GENERAL REQUIREMENTS:
 - 3.1 Material and Workmanship:
 - 3.1.1 Materials: Materials shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments.
 - 3.1.2 Workmanship: Workmanship shall be consistent with high-grade aircraft instrument manufacturing practice.
 - 3.2 Identification: The following information shall be legibly and permanently marked on the instrument or attached thereto:
 - a. Name of instrument (Climb Indicator)
 - b. Aeronautical Standard AS-394A
 - c. Manufacturer's part number
 - d. Manufacturer's serial number or date of manufacture
 - e. Manufacturer's name and/or trademark
 - f. Range
 - 3.3 Environmental Conditions: The following conditions have been established as design requirements only. Tests shall be conducted as specified in Section 5, 6 and 7.
 - 3.3.1 Temperature: When installed in accordance with instrument manufacturer's instructions, the instrument shall function over the range of ambient temperature of -30C and 50C and shall not be adversely affected by exposure to temperatures of -55C to 70C.
 - 3.3.2 Humidity: The instrument shall function and shall not be adversely affected when exposed to any relative humidity in the range from 0 to 95% at a temperature of approximately 32C.

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- 3.3.3 Vibration: When installed in accordance with the instrument manufacturer's instructions, the instruments shall function and shall not be adversely affected when subjected to vibration of the following characteristics:

<u>Instrument Location</u> <u>in Airframe</u>	<u>Cycles</u> <u>Per Sec.</u>	<u>Max. Double</u> <u>Amplitude (In.)</u>	<u>Maximum</u> <u>Acceleration</u>
Instrument Panel or Vibration Isolated Mount	5-50	0.020	1.5g

- 3.3.4 Altitude: The instrument shall function and shall not be adversely affected when subjected to a pressure and temperature range equivalent to -1,000 to 40,000 feet standard altitude, per NACA Report Number 1235, except as limited by the application of paragraph 3.3.1. The instrument shall withstand an external case pressure of 50 inches Hg absolute when installed properly and vented to atmospheric pressure.
- 3.4 Magnetic Effect: The magnetic effect of the indicator shall not adversely affect the operation of other instruments installed in the same aircraft.

4. DETAIL REQUIREMENTS:

- 4.1 Indicating Method: Ascent shall be indicated by a clockwise rotation of the pointer from the zero at the 9 o'clock position. Descent shall be indicated by a counterclockwise rotation. Stops shall be incorporated to limit the pointer movement to not more than 178 degrees in each direction from zero.
- 4.2 Dial Markings:
- 4.2.1 Finish: Unless otherwise specified by the user, matte white material shall be applied to major graduations, numerals and pointers. Non-functional surfaces shall be a durable dull black.
- 4.2.2 Graduations: Markings may be provided as follows:
- TYPES I AND II - Markings at 100 FPM intervals with major graduations at 500 FPM intervals.
- TYPES III AND IV - Markings at 100 FPM intervals up to 2,000 FPM with major graduations at 500 FPM intervals.
- 4.2.3 Numerals: Sufficient numerals shall be marked to positively and quickly identify all graduations. Numerals shall distinctly indicate the graduations to which each applies.
- 4.2.4 Instrument Names: Instrument name or function it measures may be legibly indicated in the same finish as applied to the major graduations and numerals.

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- 4.2.5 Visibility: Pointer and dial markings shall be visible from any point within the frustum of a cone, the side of which makes an angle of not less than 30 degrees with the perpendicular to the dial and the small diameter of which is the aperture of the instrument case. The distance between the dial and the cover glass shall be a practical minimum and shall not exceed 0.250 of an inch.
- 4.3 Zero Setting System: If means for manually setting the pointer at zero is provided, it shall not be accessible in flight.
5. TEST CONDITIONS:
- 5.1 Atmospheric Conditions: Unless otherwise specified, all tests required by this Aeronautical Standard shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 25C. When tests are conducted with the atmospheric pressure or the temperature substantially different from these values, allowance shall be made for the variation from the specified condition.
- 5.2 Vibration (to minimize friction): Unless otherwise specified, all tests for performance may be conducted with the instrument subjected to a vibration of 0.002 to 0.005 inch double amplitude at a frequency of 1500 to 2000 cycles per minute. The term double as used herein indicates the total displacement from positive maximum to negative maximum.
- 5.3 Vibration Equipment: Vibration equipment shall be used which will provide frequencies and amplitudes consistent with the requirements of paragraph 3.3.3 with the following characteristics.
- 5.3.1 Circular Motion Vibration: Vibration equipment shall be such that a point on the instrument case will describe in a plane inclined 45 degrees to the horizontal plane, a circle, the diameter of which is equal to the double amplitude specified.
- 5.4 Position: Unless otherwise specified, all tests shall be made with the instrument mounted in its normal operating position.
6. INDIVIDUAL PERFORMANCE REQUIREMENTS: All instruments shall be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this aeronautical standard including the following requirements where applicable.
- 6.1 Zero Setting Range: The range of movement of the pointer by means of the zero adjustment shall not be less than 400 feet per minute for the "Up" and "Down" position.
- 6.2 Scale Error: When subjected to the rates of change of pressure indicated in Table I for the altitude intervals shown, the errors shall not exceed the tolerances specified.

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- 6.3 Lag: The natural lag of the instrument when timed between the following points shall be between 3 and 15 seconds.
- TYPE I AND II - 1800 - 200 feet per minute
TYPE III AND IV - 2000 - 200 feet per minute
- 6.4 Friction: A test shall be performed to ascertain friction. In the time intervals at which the lag times were measured, the pointer shall move smoothly towards zero (while no vibration is applied) and shall return to zero within 300 feet of the initial reading.
- 6.5 Leak: With a suction of 15 inches of mercury applied to the static pressure connection, the leakage shall not cause more than 0.05 inches of mercury pressure drop during a 1 minute period. With a pressure of 10 inches of mercury applied to the static connection, the leakage shall not cause more than 0.05 inches of mercury pressure drop during a 1 minute period.
- 6.6 Position Error: With atmospheric pressure applied to the instrument, the difference between the pointer indication when the instrument is in normal operating position and when it is in any other position shall not exceed 50 feet per minute.
7. QUALIFICATION TESTS: As many instruments as deemed necessary, to demonstrate that all instruments will comply with the requirements of this section, shall be tested in accordance with the manufacturers' recommendations.
- 7.1 Low Temperature: The instrument shall be exposed to a temperature of -30°C for 3 hours and while at this temperature shall be subjected to the rates of change of pressure indicated in Table II for the altitude intervals shown. The errors shall not exceed the tolerances specified in Table II.
- 7.2 Extreme Temperature Exposure: The instrument shall, after alternate exposures to ambient temperatures of -65°C and 70°C for periods of 24 hours each and a delay of 3 hours at room temperature following completion of the exposure, meet the requirements of paragraphs 6.2, 6.3 and 6.4. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified herein.

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- 7.3 Vibration: The instrument shall be subjected to a resonant frequency survey of the appropriate range specified in paragraph 3.3.4 in order to determine if there exists any resonant frequencies of the parts. The amplitude used may be any convenient value that does not exceed the maximum double amplitude and the maximum acceleration specified in paragraph 3.3.4.

The instrument shall then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in paragraph 3.3.4 at the resonant frequency for a period of one (1) hour with circular motion vibration. When more than one (1) resonant frequency is encountered, a test period may be accomplished at the most severe resonance, or the period may be divided among the resonant frequencies, which shall be considered most likely to produce failure. The test period shall not be less than one-half hour at any resonant mode. When resonant frequencies are not apparent within the specified frequency range, the instrument shall be vibrated for two (2) hours in accordance with the vibration requirements' schedule (Section 3) at the maximum double amplitude and the frequency to provide the maximum acceleration.

While the instrument is being vibrated, the drift of the pointer shall not exceed 50 feet per minute and it shall not oscillate more than 50 feet per minute.

After completion of the exposure no damage shall be evident and the instrument shall meet the requirements of paragraph 6.2, 6.3 and 6.4.

- 7.4 Overpressure: After subjecting the instrument to rates of 20,000 feet per minute ascent and 30,000 feet per minute descent, within a 5 minute period the pointer shall return to its original indication within 100 feet per minute.
- 7.5 Magnetic Effects: The magnetic effect of the instrument shall be determined in terms of the deflection of a free magnet, approximately 1-1/2 inches long, in a magnetic field with a horizontal intensity of 0.18 ± 0.01 gauss, when the indicator is held in various positions on an east-west line with its nearest part 12 inches from the center of the magnet. (An aircraft Compass with the compensating magnets removed therefrom may be used as the free magnet for this test.) The maximum deflection of the magnet shall not exceed 5 degrees.
- 7.6 Humidity: The instrument shall be mounted in its normal operating position (with simulated installation conditions by connecting 10 feet of coiled copper tubing to the pressure connection in such a manner that moisture can drain out the open end) in the chamber maintained at a temperature of 70 ± 20 and a relative humidity of $95 \pm 5\%$ for a period of six (6) hours. After this period, the heat shall be shut off and the instrument shall be allowed to cool for a period of 18 hours in this atmosphere in which the humidity rises to 100% as the temperature decreases to not lower than 38C. This complete cycle shall be conducted once.

Immediately after cycling, the instrument shall be tested and shall meet the requirements of Section 6.

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TABLE ISCALE ERROR TOLERANCETYPES I and II

(Ranges: 0-2,000 and 0-3,000 Feet Per Minute)

	<u>Standard Altitude Test Interval Feet</u>	<u>Test Rate Ascent and Descent Feet Per Minute</u>	<u>Tolerance Feet Per Minute</u>
Between	2,000 to 2,500	500	35
	2,000 to 3,000	1,000	75
	2,000 to 3,500	1,500**	150
	2,000 to 4,000	2,000	250
Between	15,000 to 16,500	1,500**	200
	15,000 to 17,000	2,000	250
Between	28,000 to 29,500	1,500**	200
	28,000 to 30,000	2,000	250

** Maximum test point for Type I.

TYPES III and IV

(Ranges: 0-4,000 and 0-6,000 Feet Per Minute)

	<u>Standard Altitude Test Interval Feet</u>	<u>Test Rate Ascent and Descent Feet Per Minute</u>	<u>Tolerance Feet Per Minute</u>
Between	2,000 to 2,500	500	100
	2,000 to 3,000	1,000	200
	2,000 to 4,000	2,000	300
	2,000 to 5,000	3,000**	300
	2,000 to 6,000	4,000	400
	2,000 to 7,000	5,000	500
Between	15,000 to 17,000	2,000**	300
	15,000 to 17,000	4,000	400
Between	28,000 to 30,000	2,000**	300
	28,000 to 32,000	4,000	400

** Maximum test point for Type III.

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TABLE II

SCALE ERROR
LOW TEMPERATURE TOLERANCE

TYPES I and II
(Ranges: 0-2,000 and 0-3,000 Feet Per Minute)

<u>Standard Altitude Test Interval Feet</u>	<u>Test Rate Ascent and Descent Feet Per Minute</u>	<u>Tolerance Feet Per Minute</u>
Between 2,000 to 3,500	1,500	200
Between 28,000 to 29,500	1,500	250

TYPES III and IV
(Ranges: 0-4,000 and 0-6,000 Feet Per Minute)

<u>Standard Altitude Test Interval Feet</u>	<u>Test Rate Ascent and Descent Feet Per Minute</u>	<u>Tolerance Feet Per Minute</u>
Between 2,000 to 4,000	2,000**	300
2,000 to 6,000	4,000	400
Between 28,000 to 30,000	2,000**	300
28,000 to 32,000	4,000	400

** Test Point for Type III.

NOTE: Tables I and II have been changed in accordance with Military format; i.e., the values have not been changed.

PREPARED BY SAE COMMITTEE A-4, AIRCRAFT INSTRUMENTS